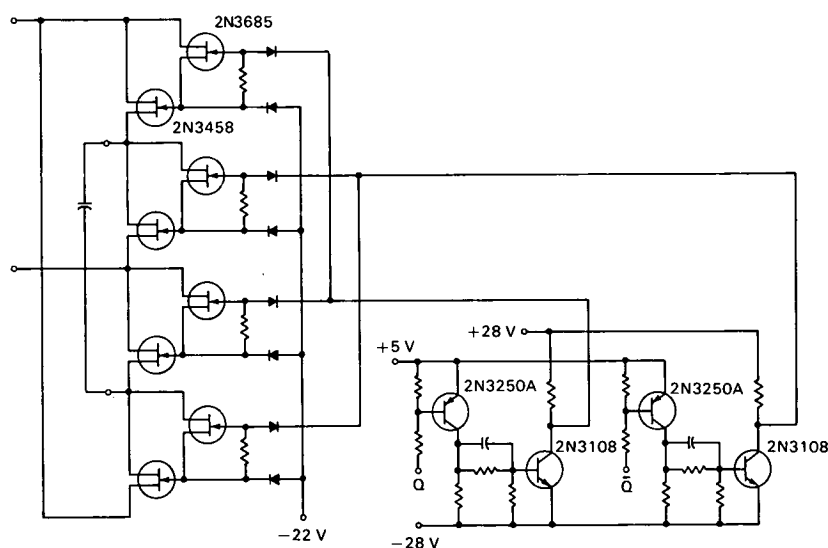


# NASA TECH BRIEF

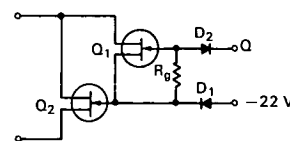


NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

## Solid-State Switch Increases Switching Speed



Solid-State DPDT Switch



Single-Pole Single-Throw Switch

### The problem:

To develop a switch for commutating capacitors in an RC commutated network that will provide greater switching speed and extend the filtering or commutating frequency spectrum well into the kilocycle region. In the past, electromechanical relays were used in the input and feedback networks of operational amplifiers where a high degree of isolation was required. These relays limited the switching speed and symmetry which could be obtained, as well as longevity and power consumption.

### The solution:

A solid-state switch which is equivalent to the standard double-pole double-throw (DPDT) relay and is

driven from digital micrologic circuits. Four of these switches are used in a 4-phase commutating arrangement which yields a modified notch filter characteristic. The switches are connected in series and may be used either in the input or feedback network of a differential amplifier. The switch was designed to be compatible with signal levels between  $\pm 14$  volts.

### How it's done:

Each DPDT switch basically consists of four single-pole single-throw (SPST) switch equivalents. The control input to the switch, Q, is either  $\pm 28$  volts. When Q is  $-28$  volts, diodes D<sub>1</sub> and D<sub>2</sub> are forward biased impressing a voltage of about 5 volts across R<sub>g</sub>. Since the pinch-off voltage of Q<sub>1</sub>, which is a 2N3685, is only

(continued overleaf)

3.5 volts, the potential across  $R_g$  is more than adequate to maintain  $Q_1$  in the cutoff condition. The base of  $Q_2$  is connected to the -22 volt supply through diode  $D_1$  and maintains  $Q_2$  in the cutoff condition as long as the drain and source voltage are more positive than -14 volts. This restriction is necessary since the pinch-off voltage of  $Q_2$ , which is a 2N3458, is 8 volts maximum. The pinch-off voltage of both transistors is specified at a drain to source current of 1 nanoamp. As a result, only a very small drain-to-source current flows through the switch in the cutoff condition. Additional leakage currents on the order of 0.1 nanoamp flow from the source and drain to the gate.

When the  $Q$  input is at +28 volts, diodes  $D_1$  and  $D_2$  are reverse biased forcing the switch into the conducting stage. With both diodes reverse biased, the voltage across  $R_g$  decays to zero which turns on transistor  $Q_1$ . Since transistor  $Q_1$  is connected from the gate-to-source of  $Q_2$ , it also turns on transistor  $Q_2$ . The on resistance of  $Q_1$  is approximately 800 ohms while the on resistance of  $Q_2$  is about 200 ohms. Since only the resistance of  $Q_2$  is in the signal path, the switch has a series resistance of about 200 ohms.

The magnitude of  $R_g$  in part determines the speed of the switch, since it provides a discharge path for the gate capacitance. Additional capacitance may be added across diode  $D_2$  to improve the turn-on characteristics. Using 1N4443 gating diodes and  $R_g=68k$ , switching speeds on the order of 1 microsecond are obtained.

Four SPST switches are used in each DPDT relay equivalent, however only two of the SPST switches are on at any one time. As a result the DPDT switch has a total resistance of 400 ohms in the on condition. Leakage in the off condition is on the order of tenths of a nanoamp at room temperature.

The actual control signals,  $Q$  and  $\bar{Q}$ , to switch shown in circuit on the left, are 0 to +5 volt micrologic signals. A two-switch driver is used to convert this to the required  $\pm 28$  volt gating signal.

**Note:**

Inquiries concerning this invention may be directed to:

Technology Utilization Officer  
Western Operations Office  
150 Pico Boulevard  
Santa Monica, California 90406  
Reference: B66-10430

**Patent status:**

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: G. F. McGowan  
of Martin-Marietta Corporation  
under contract to  
Western Operations Office  
(WOO-298)